Dr. Koji Mukai
Black Hole Problem Set
Date Due: February 27 2001

Homework Questions

1. Mass function:

   - Cygnus X-1 has P=5.6 days and $K_2 = 76$ km s^{-1}. What is its mass function, is the units of solar masses (use $1 M_\odot = 2 \times 10^{33}$ g)?
   - If M_2 is unknown, is there a solution allowed in which $M_1 < 2.0 M_\odot$ for Cyg X-1?
   - The SXT XTE J1118+480 has P=0.17 days and $K_2 = 709$ km s^{-1}. What is its mass function?
   - If M_2 is unknown, is there a solution allowed in which $M_1 < 2.0 M_\odot$ for XTE J1118+480?

2. Imagine that you have just built an adaptive optics infrared camera with an angular resolution of 0.1 arcsec (that is, a point-like source appears to have a disk of about 0.1 arcsec diameter), and that you can determine the position of bright stars accurate to 0.01 arcsec. You set out to observe the galactic center, assumed to be 8 kpc away (1 kpc = 1,000 pc; 1 pc = 3.1×10^{18} cm).

   - At the distance of the Galactic center, what linear distance does an angular separation of 0.1 arcsec correspond to?
   - If a star is in a circular Keplerian orbit around a million solar mass black hole with an orbital separation corresponding to the above distance, what would its velocity be? (Please express the answer in km s^{-1} to make it human-friendly.)
   - If a star along a straight line at the above velocity, how much (linear distance) does it move in a year? If that movement is entirely in the plane of the sky, how much (angular distance) does it move in a year?
   - Given the above simplified calculations, is your instrument useful in determining the existence or otherwise of a SMBH at the center of our Galaxy?

The answers are due on 2001 February 27th.